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THE HESSIAN FLY

AND HOW TO PREVENT LOSSES FROM IT

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THE HESSIAN FLY undoubtedly is the most injurious insect enemy of wheat in the United States. During the last 37 years at least seven general outbreaks of this pest have occurred in the States east of the Mississippi River. These invasions have averaged about one every five years, although they have occurred at rather irregular intervals. The last one was very destructive and was at its height during the period from 1914 to 1916.

In some years a toll of approximately $16,000,000 has been taken in Kansas alone, and the average annual damage to wheat throughout the United States has been estimated at $50,000,000.

A large proportion of such losses is preventable, although no remedy is known which will destroy the pest or save the crop once it has become thoroughly infested. Control and preventive measures are described on page 13 and summarized on page 16.

The control measures recommended in this bulletin are not adapted to the Pacific coast region, where studies are still under way.

THE HESSIAN FLY[1] AND HOW TO PREVENT LOSSES FROM IT.

CONTENTS.

ECONOMIC IMPORTANCE.

IN THE principal winter wheat-growing regions of the United States the Hessian fly is the most injurious insect enemy of the wheat crop. It is generally distributed throughout this territory, except in the extreme south, and is always alert to take advantage of favorable weather and crop conditions to multiply rapidly. Damage amounting to at least $100,000,000 in a single year has been known to occur from its work.

The Hessian fly is chiefly injurious to wheat, but at times injures barley and rye to a lesser extent. It does not attack oats at all. In a few instances, apparently, the insect has been reared from grasses, but it is not known to infest them except under unusual conditions.

REGIONS WHERE THE HESSIAN FLY IS MOST INJURIOUS.

The preferred nome of the Hessian fly, generally speaking, is that portion of the country lying east of the one hundredth meridian and between the thirty-fifth and forty-fifth parallels of north latitude. It occurs outside of this area, but usually not as a serious menace to the wheat. The fly also is found in the Pacific Coast region, but is not nearly so destructive as it is east of the Rocky Mountains.

The Hessian fly is found in the Dominion of Canada from Prince Edward Island to Indian Head, Saskatchewan, and also in British

[1] *Phytophaga destructor* Say; order Diptera, family Itonididae.

Columbia. Outside of America, it is known in North Africa, Western Asia, Europe, Great Britain, and New Zealand.

The map (fig. 1) shows the distribution of the insect in the United States. The common name, "Hessian fly," was bestowed upon this insect long ago by Americans, because of its depredations on Long Island, N. Y., in 1779, in the vicinity of Lord Howe's encampment of three years before. On the supposition that the pest had been brought from their native country in the straw used for their bedding by the Hessian mercenaries who constituted a part of this army, it was given the obnoxious name of "Hessian fly." The pest undoubtedly was imported, probably from some trans-Atlantic country, some time during the latter half of the eighteenth century.

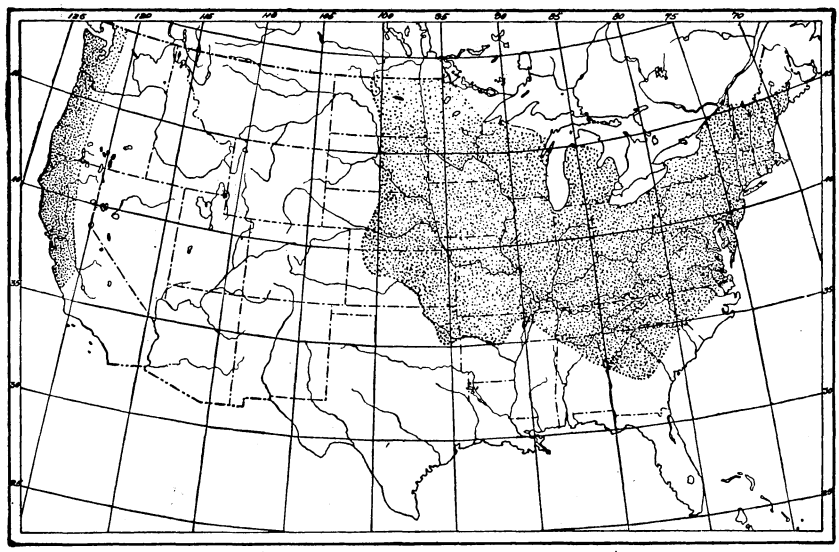

FIG. 1.—Map showing distribution of the Hessian fly in the United States.

NATURE OF INJURY.

The Hessian fly injures wheat and other plants by extracting the juices of the young growing plants and by weakening the stems of the older wheat near the joints and causing it to become "straw-fallen" shortly before harvest.

The most obvious damage is caused by the maggot or larva of the spring generation, which lodges between the leaf sheath and the stem above a joint. Frequently several maggots locate above the same joint. The maggots weaken the stem, causing it to become shrunken at their point of contact with it. As the plant grows it may become so weakened at the place where the fly is developing that it breaks over before harvest and is not reached by the harvesting machinery. In many cases the infested straw, instead of producing a plump head, produces one containing shriveled grain. The heads

may even appear white at harvest time as if blasted. In cases of serious infestation much of the young wheat is killed outright by the work of the fall brood of maggots.

EFFECT OF LARVÆ ON THE PLANT.

The effect of the feeding of the larvæ on a young wheat plant is very marked and may be observed soon after the young reach the

FIG. 2.—Healthy young wheat plant.

stem under the sheath. Once seen it usually is possible afterwards to detect an infested plant.

For comparison, illustrations are given of a normal young plant (fig. 2) and an infested young plant (fig. 3). An uninfested

plant is of a more slender growth, the green color is lighter, with a slight tinge of yellow, the stems are more or less visible, and the central unfolding leaf is present. The whole plant is inclined to droop and the tillers spread out and cover the ground. In an infested tiller the leaves are broader, usually shorter and of a deep dark-green color, somewhat resembling those of oats. The leaves

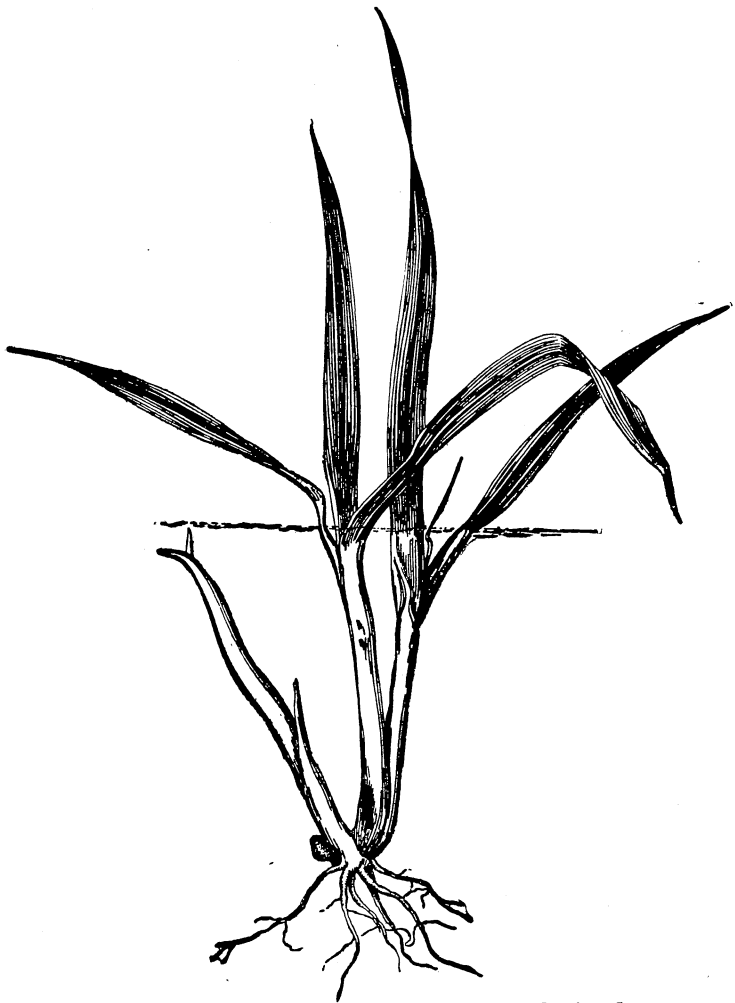

FIG. 3.—Young wheat plant infested by the Hessian fly.

stand more erect and rise directly from the ground without a visible stem. Infested tillers usually perish during the winter. Figure 3 shows a young tiller starting out from below the part attacked by the fly. If this is attacked after it appears above ground it assumes the same appearance as the original plant. Its leaves become broader and of a darker color. The foregoing statement applies equally to

a severe attack on fall wheat in spring or on young spring wheat. The only exception in the appearance of infested young plants is in the case of the hard wheats, whose foliage is naturally of a darker color, but the erect position will still enable the observer to detect the infestation. Of course, later on the infested plants change to yellow and then brown, but the darker color and rank growth of leaf always precede this.

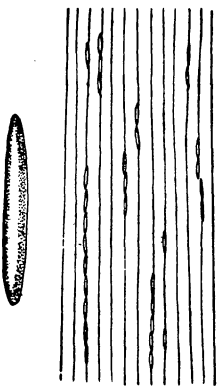

FIG. 4.—Egg of Hessian fly, greatly enlarged; section of leaf of wheat, at right, showing eggs as usually deposited, less enlarged.

LIFE HISTORY.

In the winter-wheat regions of this country the Hessian fly usually has two principal generations annually. In the South the two generations are the most widely separated, while in the North, in the regions of spring-wheat growing, one generation seems to follow the other in quick succession.

Throughout the winter wheat-growing sections the fly passes the winter in the young wheat, mostly in the resting or "flaxseed"[1] stage, but in mild winters to some extent as larvæ from two-thirds to full grown.

In spring (from March in Georgia and South Carolina to May in Michigan) the flies escape from the "flaxseeds" in these young plants, deposit their eggs on the wheat (fig. 4), and the young from these develop to "flaxseeds" (fig. 5) before harvest, passing the summer in the stubble. During some seasons and in certain localities there occasionally appears just before harvest what has by some been considered a "supplementary" second brood of flies, consisting of a fractional part of the spring brood, the development of which has been delayed.

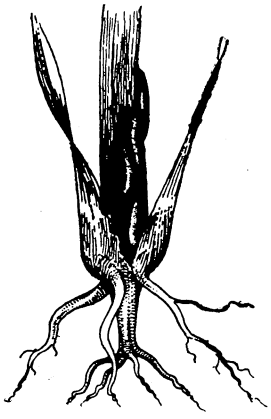

FIG. 5.—Hessian fly "flaxseeds" on young wheat. Much enlarged.

In autumn the order of appearance of flies is reversed. In northern Michigan the flies of the fall generation may be found, under normal meteorological conditions, during the last days of August and first days of September. In Georgia and South Carolina, under the same conditions, it may be the last of November or the first of December before they have all left the stubble. Thus has this insect adapted itself to the prolonged southern summer, during

[1] The so-called "flaxseed" of the Hessian fly is described in detail on page 9.

which there is little or no food for the larvæ. While there are stragglers, the major part of the generation usually appears and disappears within the space of a week or so, and the flies, by preference, deposit their eggs on the younger plants, those with one or two leaves seeming to suit them best. When hatched at this time of the year the young maggots make their way downward nearly or quite to the roots (fig. 6). Normally these individuals complete their development as larvæ, pass into the "flaxseed" stage, and spend the winter as such on the young wheat plants (fig. 5). The earliest-deposited eggs on the earliest-sown wheat, however, under favorable conditions may produce adults before the winter sets in, and the delayed individuals of the fall brood of flies occurring at this time combine with them to produce another so-called "supplementary generation." The importance of this "supplementary generation," so called, depends much on the weather. If winter sets in before the larvæ have matured sufficiently to withstand its rigors, these necessarily perish, while if the mild autumn weather is greatly prolonged, a greater or less number of them may winter over uninjured.

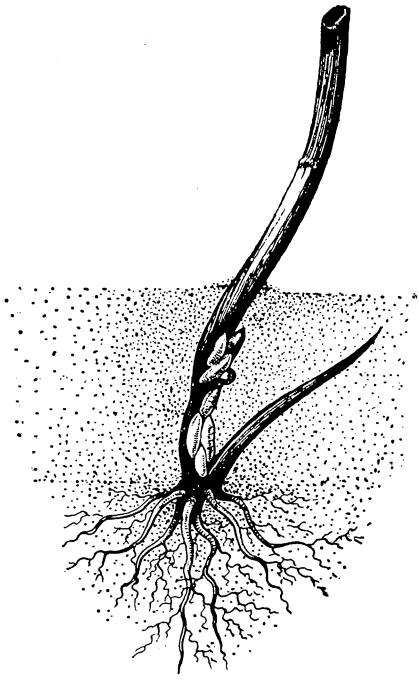

FIG. 6.—Hessian fly maggots beneath sheath in the soil. Enlarged.

It has been found, under certain weather conditions, that in fields containing volunteer wheat partial generations of the fly may occasionally appear. These are known as "supplementary broods," and it is possible for the earliest flies in volunteer wheat to emerge and reinfest the winter wheat.

DESCRIPTION AND LOCATION OF VARIOUS STAGES.

The egg (fig. 4, at left) is very minute, being only about one-fiftieth of an inch in length, but it may be readily seen by one having ordinarily good sight. It is slender and almost cylindrical, with both ends bluntly rounded. The surface of the egg is glossy and its color a shade of vermilion red, which deepens with age. The eggs are generally placed in the grooves of the upper surface of the leaves (fig. 4, at right).

The newly hatched larva is slightly smaller than the egg and has the same general color, but this changes to white within a few days. Immediately after it is hatched it makes its way down the leaf and behind the sheath. In the case of young wheat it descends to just above the roots, but after the plants have begun to joint it can go no farther than the base of the sheath belonging to that particular leaf, which is always at the joint. Where excessively abundant the larvæ crowd together side by side or behind one another under the same sheath. This condition usually accompanies a heavy infestation.

The fall generation of larvæ and the overwintering "flaxseeds" are to be found just above the roots and below the surface of the ground (fig. 6). In the spring generation the larvæ, or "flaxseeds," are to be found in different locations, depending apparently upon atmospheric conditions. Thus in the eastern or more humid regions they usually occur near the joints at some distance above

FIG. 7.—The Hessian fly: Larva before "flaxseed" is formed. Greatly enlarged.

FIG. 8.—The Hessian fly: Puparium or "flaxseed." Greatly enlarged

FIG. 9.—The Hessian fly: Pupa taken from "flaxseed." Greatly enlarged. (Marlatt.)

the surface of the soil, but in the western and drier portions of its range the insect locates lower down the stem, and may be found beneath the sheaths at or even below the surface of the soil (fig. 6).

When the larva becomes full grown it is naked, glistening, and white in color (fig. 7). The skin soon hardens and turns brown, and the insect then resembles very closely a flaxseed (fig. 8), and often is referred to by that name. This is not the pupa (fig. 9), which is formed subsequently, after the larva has reversed its position and lies with the head pointing upward.

Before the fly issues, if the "flaxseed" is not situated conveniently for the emergence of the adult, the pupa pushes itself, if possible, to such a point of escape, and frequently empty pupa skins may be observed protruding from under the sheaths of leaves.

The fly itself is not easily observed until one becomes familiar with its appearance and looks for it at the right time. These facts account for the great variety of insects that are continually mistaken

by growers for the Hessian fly. Much of this confusion may be obviated if search is made for an insect like that shown in figures 10 and 11, but very minute and somewhat resembling a mosquito. During warm days, in the egg-laying season, the flies may be observed flying about in the young wheat, alighting upon the leaves. On cooler days, or in early morning while a heavy dew is on, they are down among the leaves or even on the ground. The adult flies live only a few days, depending somewhat upon temperature conditions.

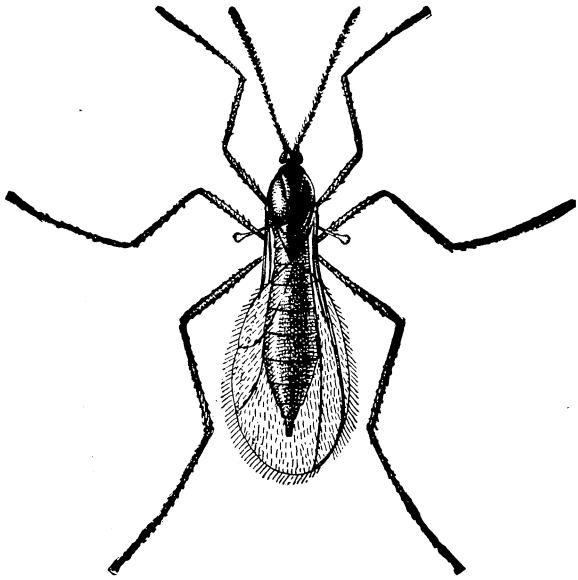

FIG. 10.—The Hessian fly: Adult female. Greatly enlarged.

EFFECT OF THE WEATHER ON THE HESSIAN FLY.

All who have studied the Hessian fly carefully under various field conditions during a series of years have noted that weather conditions have an important influence on the insect, and in the application of preventive measures these weather conditions become of vital importance.

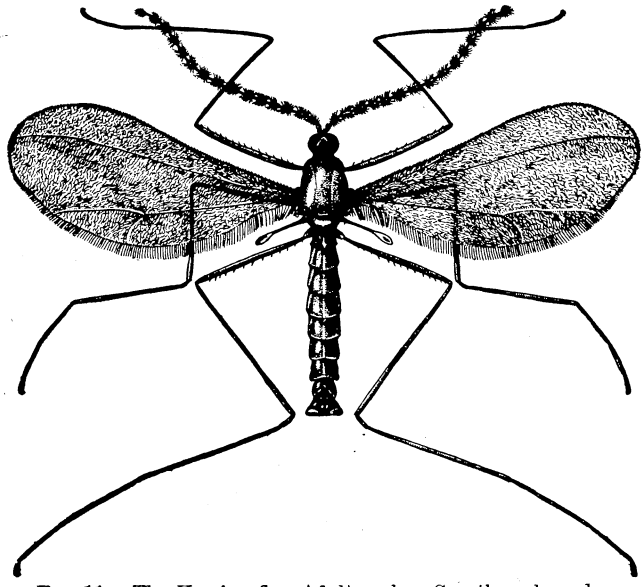

FIG. 11.—The Hessian fly: Adult male. Greatly enlarged.

Many wheat growers believe in the effectiveness of cold weather or even of frosts in terminating the activities of the flies in the fall, and it is for this reason that many growers try to delay wheat sowing until after there has

been a sharp frost. The facts are, however, that the females may be found ovipositing in rather cold weather, and the eggs have been known to remain in a temperature of 36° F. for 72 hours with no other effect than to delay their hatching that much longer. Eggs have been observed hatching during the day in the fields when there were frosts nearly every night. It should be understood clearly that the immunity of late-sown wheat from attack by the fly is not due to frost, but to the fact that by the time severe frosts occur most of the flies usually have disappeared.

The most marked influence of climatic conditions on this insect is seen in the effect of heat and drought, and especially of the two combined. Heat and drought delay the emergence of the adult Hessian flies in the fall. This fact is of special importance in the North, where it is necessary to get the wheat sown early enough to enable the plants to stand the severe weather. The larvæ in the "flaxseed" form have been known to survive for more than two years and afterwards to emerge as adults.

THE SO-CALLED BIOCLIMATIC LAW AND ITS APPLICATION IN HESSIAN-FLY CONTROL.

Many years ago it became known, through experiments conducted in Ohio by the late Prof. F. M. Webster,[1] that wheat sown on certain dates in the fall was usually immune to infestation by the Hessian fly. It was established that these dates became later at a more or less uniform rate as one progressed southward.

About a year later Dr. A. D. Hopkins[2] published information showing the rate at which the safe date varied with latitude and elevation above sea level. Recently he has shown that these safe sowing dates vary also with longitude.[3] The law as at present understood[4] and as applied to the safe sowing dates is as follows:

> The law is founded on the determined country-wide average rate of variation in the time at which periodical events, such as the emergence of the adult Hessian flies, occur at different geographical positions. Other things being equal, this variation is at the rate of four days for each degree of latitude, five degrees of longitude, and 400 feet of altitude. Therefore, from any given place, as related to a State or county, the variation in a given periodical event is (at the rate stated) earlier northward, eastward, and upward during the fall wheat-sowing period.

There are many regional and local influences which cause more or less departure from the averages. Therefore, in the application of

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[1] WEBSTER, F. M. THE HESSIAN FLY. Ohio Agr. Exp. Sta. Bul. 107. May, 1899.

[2] HOPKINS, A. D. THE HESSIAN FLY IN WEST VIRGINIA AND HOW TO PREVENT LOSSES FROM ITS RAVAGES. W. Va. Univ. Agr. Exp. Sta. Bul. 67. August, 1900.

[3] Anyone who wishes to go more deeply into the matter should consult the Monthly Weather Review Supplement No. 9, Weather Bureau, U. S. Department of Agriculture, May 1, 1918.

[4] Scientific Monthly, June, 1919, p. 496.

the law to the selection of the safe-sowing date for any given locality, it is necessary for the grower to be guided by a specially prepared calendar of dates and rules for local application or to utilize some natural guide which, on his particular farm, is coincident with the safe time to sow wheat to escape damage from the fly.

Doctor Hopkins states that unpublished results of his recent experiments indicate quite conclusively that the first general coloring of the foliage, especially on the hickories, dogwood, birch, ash, etc., is, as a rule, coincident with the safest and best time to begin sowing wheat on any farm within the range of winter wheat culture.

Probably the safest and most convenient way for the wheat grower to secure the necessary information is to communicate with the nearest agricultural experiment station, requesting information as to the safe date for sowing wheat in his immediate locality. County farm advisers usually can secure such information promptly and are willing to aid in distributing it to the farmers of their respective counties.

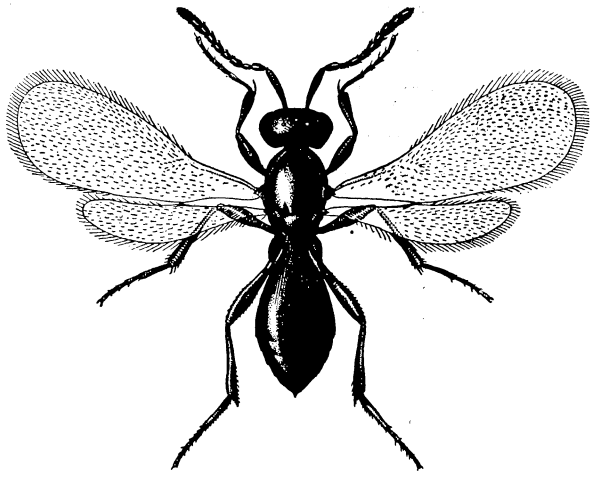

FIG. 12.—*Polygnotus hiemalis*, a parasite of the Hessian fly. Much enlarged.

NATURAL ENEMIES.

There can be no doubt that parasites play a most conspicuous part in the natural control of the Hessian fly, and if we only knew the whole truth of the matter we should find that these minute friends of the farmer are worth many times their weight in gold. Not infrequently one species of these parasites overcomes the pest in a neighborhood so effectively as almost to exterminate it. Very little is yet known regarding the laws that govern the supply of these insect enemies of the Hessian fly, and wheat growers should not rely upon them for material help. It is necessary for growers to practice at all times the preventive measures recommended in the following pages.

Polygnotus hiemalis Forbes (fig. 12) perhaps is more useful than any other insect parasite in this country in the natural control of the Hessian fly, and a considerable number of the larvæ have been observed within a single "flaxseed." The adult is black, with yellow feet and dark brown legs.

Another parasite reared almost invariably in connection with the Hessian fly is *Eupelmus allynii* French (fig. 13). It is known to be of considerable importance, although sometimes acting as a secondary parasite; that is to say, as a parasite of another Hessian fly parasite, and thus becoming injurious.

More than 20 species of insect parasites are now known to be concerned at times in the control of the Hessian fly in this country, but many of them apparently are of little importance under most conditions.

CONTROL MEASURES.

ALL USEFUL MEASURES PREVENTIVE.

Of direct remedies for the Hessian fly there is little to be said, since after the pest becomes established in a field it can not be reached

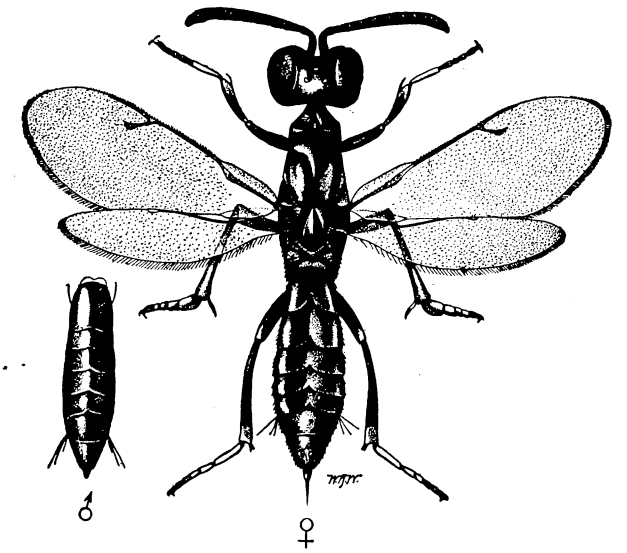

FIG. 13.—*Eupelmus allynii*, a parasite of the Hessian fly: Female, with male abdomen at left. Much enlarged.

by any measure likely to destroy it. The application broadcast of some quick-acting fertilizer, as soon as general infestation is apparent, may cause the plants to tiller more freely and give them sufficient vigor to withstand the winter and thus increase the number of healthy stems the following spring.

All useful measures necessarily must be in the nature of preventives, keeping the pest from attacking young wheat in the fall, and increasing the vigor of the young plants in order to enable them to counteract the insect's effect when present. Under the first category come late sowing, rotation of crops, the plowing under of stubble, and the destruction of volunteer wheat. Under the second should be classed the enrichment of the soil, its thorough preparation, and the selection and proper sowing of the best seed.

CROP ROTATION.

For Hessian fly control wheat should not be grown on the same land two years in succession, where it is practicable to avoid this, as the continuous planting of wheat increases infestation not only by the Hessian fly, but also by other insect pests which infest wheat stubble, such as the jointworm, the strawworm, and the wheat-stem sawflies. Such a rotation of crops should be practiced as is approved by local farm advisers or State experiment stations.

PLOWING DOWN STUBBLE.

The plowing under deeply and thoroughly of all infested wheat stubble soon after harvest is a useful practice in the control of the Hessian fly. It can not and should not be practiced, under existing systems of rotation, wherever this seriously interferes with the growing of clover or the forage grasses necessary for maintaining the proper tilth of the soil. This caution is applicable to most of the Northeastern States where the practice of sowing clover or grasses with wheat is common. In regions subject to Hessian fly injury, plowing under of stubble, where it can be practiced, however, has been found to aid materially in reducing the abundance of the pest. The plowing must be deeply and thoroughly done to be of avail. The plowed surface should be rolled afterwards or lightly harrowed to close the openings in the soil and prevent the flies from emerging.

DESTRUCTION OF VOLUNTEER WHEAT.

Volunteer wheat acts as a breeding place for the Hessian fly between regular crops and should be thoroughly eliminated by disking, plowing, or some other method.

This is very important if the main crop of wheat is to be saved from the ravages of the fly.

PROPER PREPARATION OF THE SOIL.

It matters little whether a soil has much or little fertility if that fertility is bound up in clods or hard lumps out of reach of the rootlets of the young plants. Early plowing and thorough working and compacting of the soil eliminate the lumps and clods and produce a finely pulverized, compact, moisture-conserving seed bed, from which, as soon as rootlets are sent out from the seed kernel, the shoot begins to draw nourishment. This gives vigor to the plants and thus enables them, by freely tillering, to outgrow a light attack of the fly that otherwise might prove serious.

CONSERVATION OF MOISTURE.

The seed bed should be prepared in advance of seeding. If rain occurs before the date set for sowing, the ground should be harrowed so that the wheat will germinate promptly, even if weather should turn dry. This is an important point frequently overlooked by growers.

THE USE OF GOOD SEED.

As the seed kernel contains sufficient nutriment to put out and sustain rootlets until these can begin to draw from the soil and thus support the stem, any deficiency in the seed necessarily tends to weaken the plant at the very beginning of its existence. Thus good seed becomes the first requisite in securing the healthy, vigorous plant that is to be further strengthened and sustained by a well-prepared, fertile soil. It is clear then that all shrunken, dwarfed, or otherwise imperfect kernels or weed seed, especially cockle, should be cleaned out of the seed before it is sown and only the largest and most perfect retained.

ENRICHING THE SOIL.

Wheat growing in fertile, rich soil withstands Hessian-fly injury much better than that growing in poor soil. This is true also of jointworm injury. Therefore keep the soil of wheat land in good tilth at all times by following the methods approved by agricultural experts for your particular locality.

DATE OF SOWING.

Late sowing as here recommended means moderately late sowing of fall wheat in any locality, because extremely late sowing, which sometimes has been advised, is even worse than early sowing. Experiments conducted over a period of many years have shown that in most localities the safe date for sowing winter wheat to escape Hessian fly injury in years of normal rainfall usually coincides with the proper time for sowing in order to secure maximum yields of grain. These dates as determined for some localities are as follows:

In northern Michigan, soon after the 1st of September.

In southern Michigan and northern Ohio, about September 20.

In southern Ohio, after the first week in October.

In extreme northern Illinois the safe period usually occurs from September 21 to 28.

In central Illinois and Indiana, from September 21 to 30.

In southern Illinois, from September 30 to October 10.

In central Kentucky, from October 5 to 15.

In central Tennessee, from October 15 to 25.

In Georgia and South Carolina, from October 25 to November 25.

In northeastern Kansas the safe period is from October 1 to 6.

In central Kansas, usually from October 1 in the northern part to October 12 in the southern part.

In extreme southern Kansas and northern Oklahoma wheat should not be sown until the second week in October.

This is true also of Virginia near sea level.

October-sown wheat always enjoys the greatest freedom from the fly in Maryland, except in the mountainous regions where earlier planting is necessary.

In southeastern Pennsylvania the safe period is during the last week of September, and practically the same corresponding delay in wheat sowing in the fall should be followed to the southward.

These dates are only approximate, and serve to show in a general way about the time when the fall brood of the fly disappears. All are dependent upon latitude, altitude, longitude, and other local conditions. The date varies considerably in broken or hilly country, even on the same farm, being appreciably later on the southern slope of a hill than on the northern slope of the same hill at the same elevation. Because of the fact that the larger part of the fall brood appears and is gone within a week or so, it is possible so to time the seeding of winter wheat as to avoid the Hessian fly, and this is one of the most practical and effective measures that can be applied.

SUMMARY.

There is no remedy for the Hessian fly when once it takes possession of a crop of wheat.

Injury can be prevented in only one way, namely, by keeping the fly out of the wheat.

The following methods are reliable and should all be observed where it is possible to do so:

1. Practice crop rotation. Do not sow wheat on stubble if it is possible to avoid doing so.
2. Plow under all infested stubble, where practicable, soon after harvest. Plow ruined wheat as soon as possible after it has been determined that the crop will be a failure.
3. Destroy all volunteer wheat by harrowing, disking, plowing, or some other method.
4. Plow all land to be sown to wheat as early and deeply as existing conditions permit, and prepare a thoroughly pulverized and compacted seed bed.
5. Conserve moisture against a period of drought at seeding time.
6. Use good seed.
7. Fertilize.
8. Sow wheat during the fly-free period as advised by your farm adviser or State experiment station.

Adhere to these practices every year whether the fly is abundant or scarce. They will help to keep it scarce.

Community cooperation is essential if success is to be attained because one infested field may furnish enough flies to damage the wheat for several miles around.

O